



Solar Ultraviolet Magnetograph Investigation (SUMI) Component Responses to Payload Vibration Testing.

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Overview

- Vibration testing of SUMI was performed at both the experiment and payload levels. No accelerometers were installed inside the experiment during testing, but it is certain that component responses were very high. The environments experienced by optical and electronic components in these tests is an area of ongoing concern.
- The analysis supporting this presentation included a detailed finite element model of the SUMI experiment section, the dynamic response of which, correlated well with accelerometer measurements from the testing of the experimental section at Marshall Space Flight Center. The relatively short timeframe available to complete the task and the limited design information available was a limitation on the level of detail possible for the non-experiment portion of the model. However, since the locations of interest are buried in the experimental section of the model, the calculated responses should be enlightening both for the development of test criteria and for guidance in design.



Payload

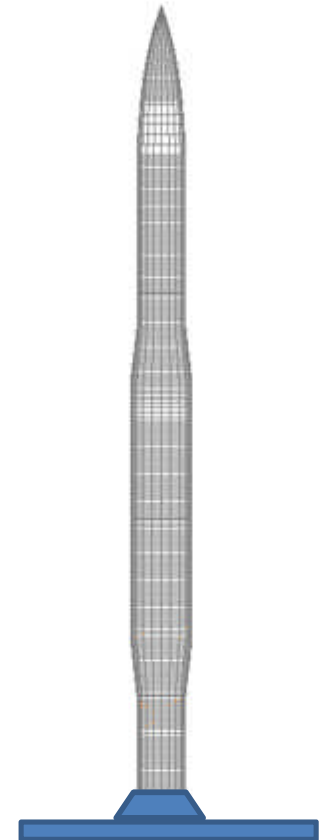


Experiment

Sounding Rocket Vibration Test Criteria (NSROC ENVIRONMENTAL TESTING POLICY MANUAL)

	Payload Test Criteria	Component Qualification
S I N E	Sweep Rate: 4 oct./min. Test Profile:	Sweep Rate: 4 oct./min. Test Profile:
	3.84 in./s 5-24 Hz	5.90 in./s 5-24 Hz
	1.53 g 24-110 Hz	2.30 g 24-110 Hz
	3.50 g 110-800 Hz	5.25 g 110-800 Hz
	10.0 g 800-2000 Hz	15.0 g 800-2000 Hz
	SAME IN ALL AXES	SAME IN ALL AXES
R A N D O M	Duration: 10 sec./axis Spectrum:	Duration 10 sec./axis Spectrum:
	12.7 grms	19.05 grms
	0.01 g ² /Hz 20 Hz	0.023 g ² /Hz 20 Hz
	0.10 g ² /Hz 1000 Hz	0.230 g ² /Hz 1000 Hz
	(on 1.8 db/oct. slope)	(on 1.8 db/oct. slope)
	0.10 g ² /Hz 1000-2000 Hz	0.23 g ² /Hz 1000-2000 Hz
	SAME IN ALL AXES	SAME IN ALL AXES

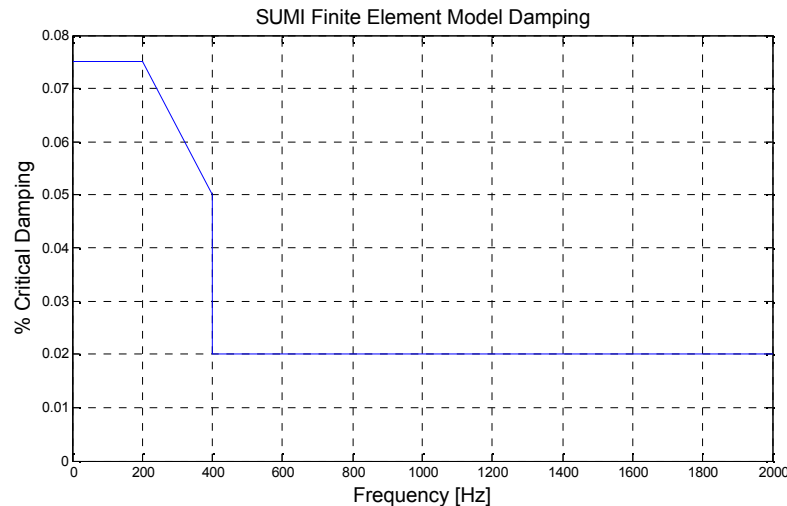
- PI's of new payloads commonly request that sine vibration only be performed on in the thrust axis.
- Component Qualification levels are used for new Black Brant avionics and do not necessarily envelope environments seen by components in the experiment section during payload testing, however these environments are often successfully used by experimenters.



Configuration for Payload vibrate

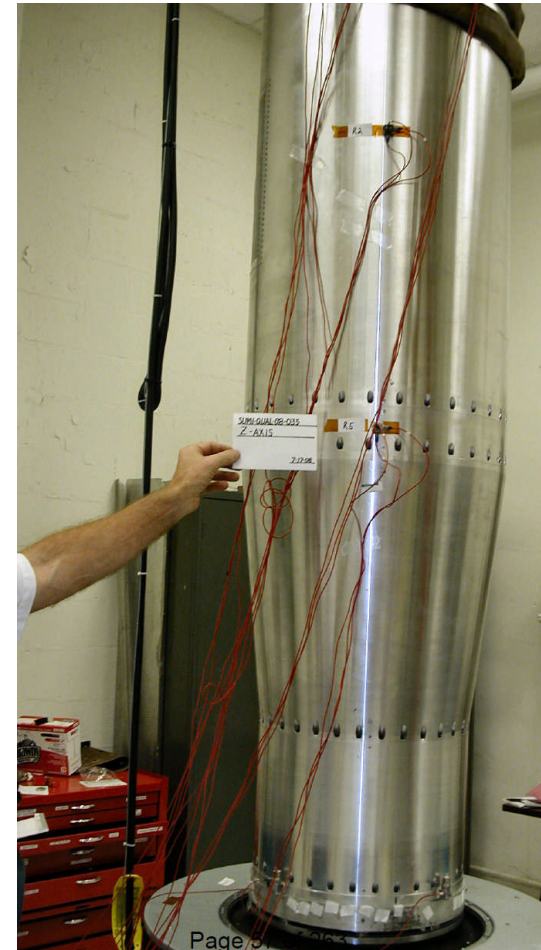
Finite Element Modeling

- Finite Element Model (200,000 degrees of freedom)
- More detail in the modeling of the experiment than the rest of the payload.
- Eigenvector solutions in Nastran
- Dynamic response to base shake inputs calculated using Matlab based on NASTRAN Modal solution and the following assumed damping spectrum. The delta frequency employed to calculate the response was 1 Hz.

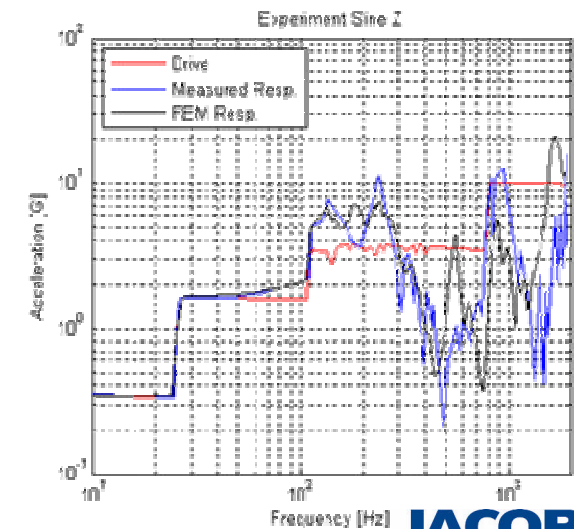
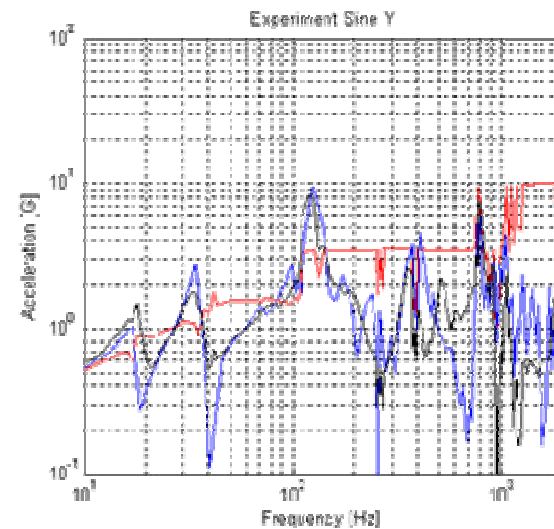
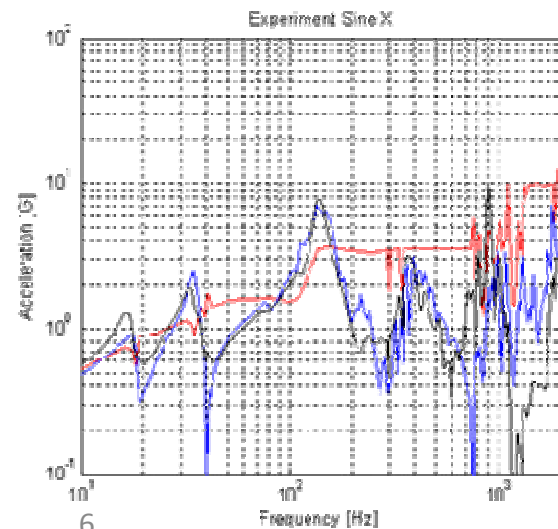
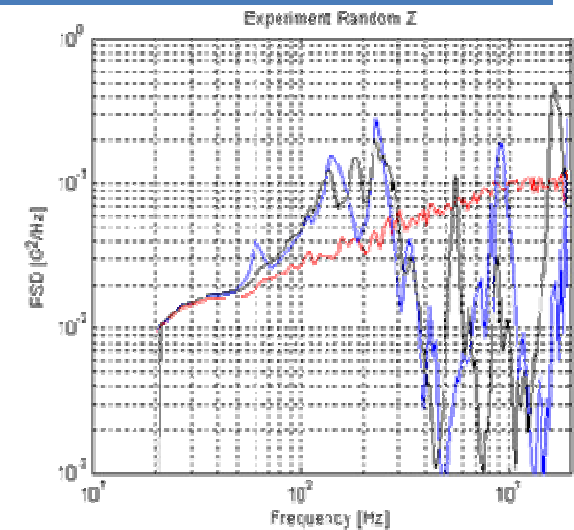
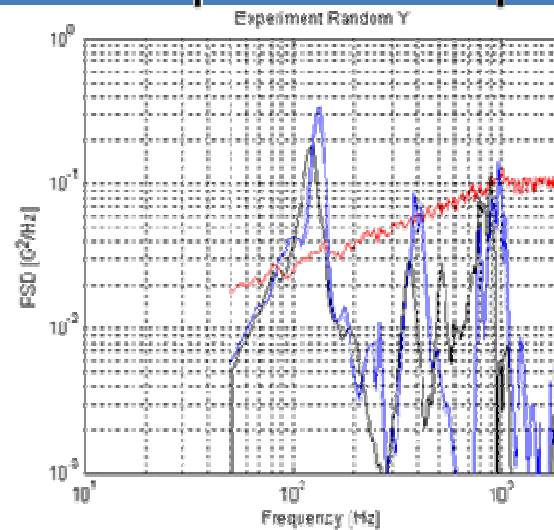
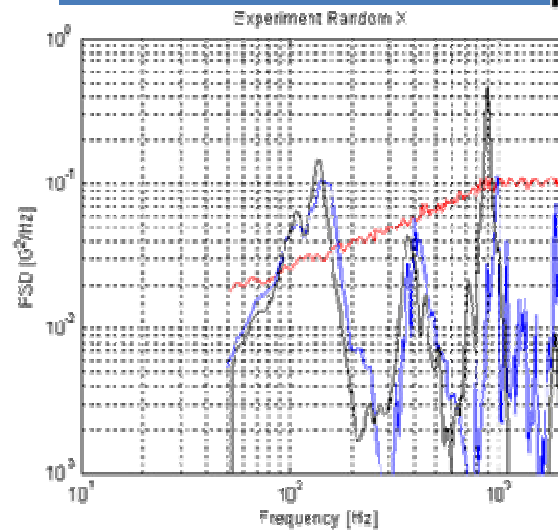


MSFC Testing

- Sine and Random Vibration testing of SUMI at MSFC consisted of the experiment section only.
 - 3-Axis Random
 - Z-axis Sine
- Finite Element Model responses compare well with accelerometer measurements.

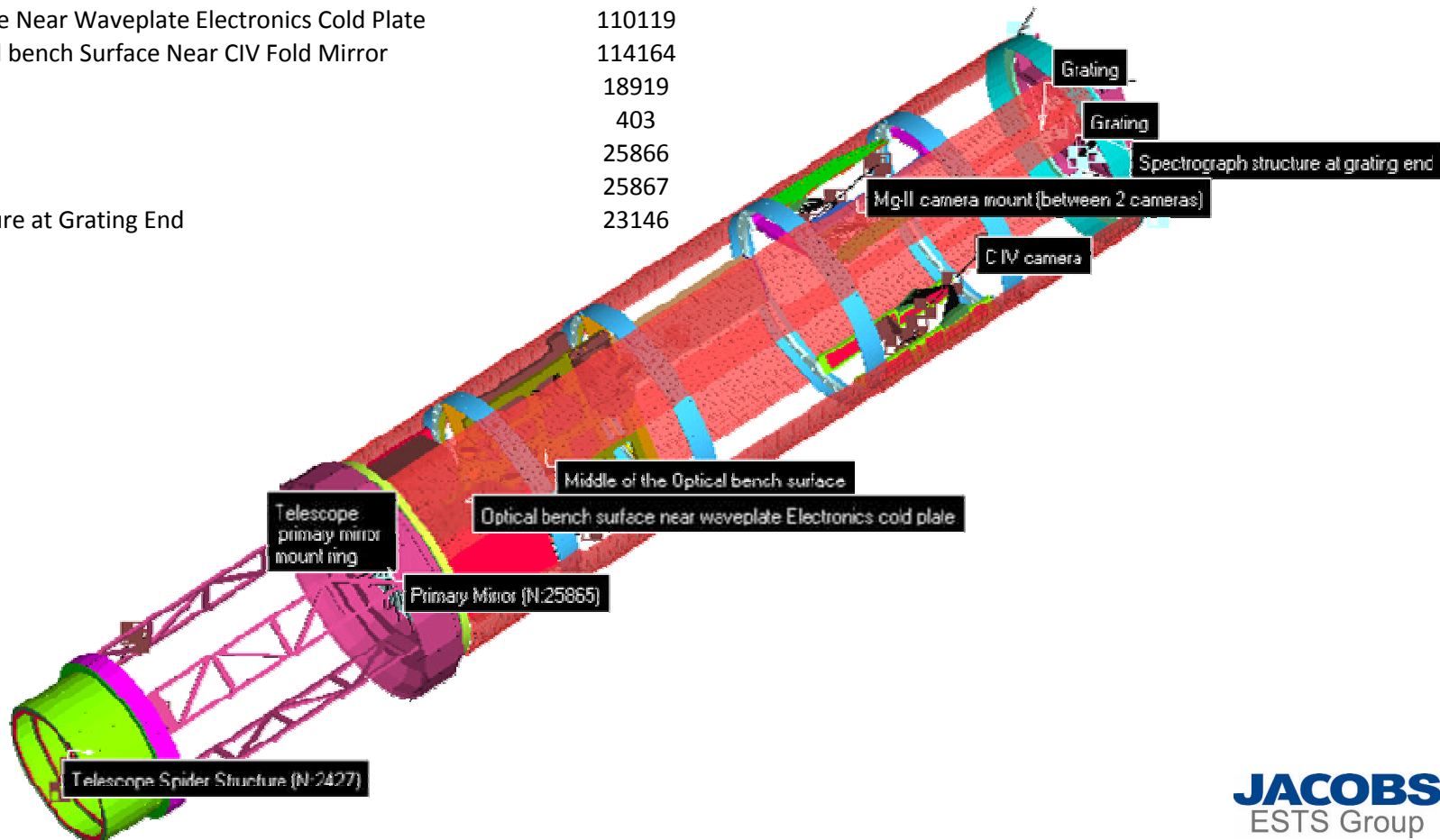


FEA Response Comparison to Experiment Vibration Test

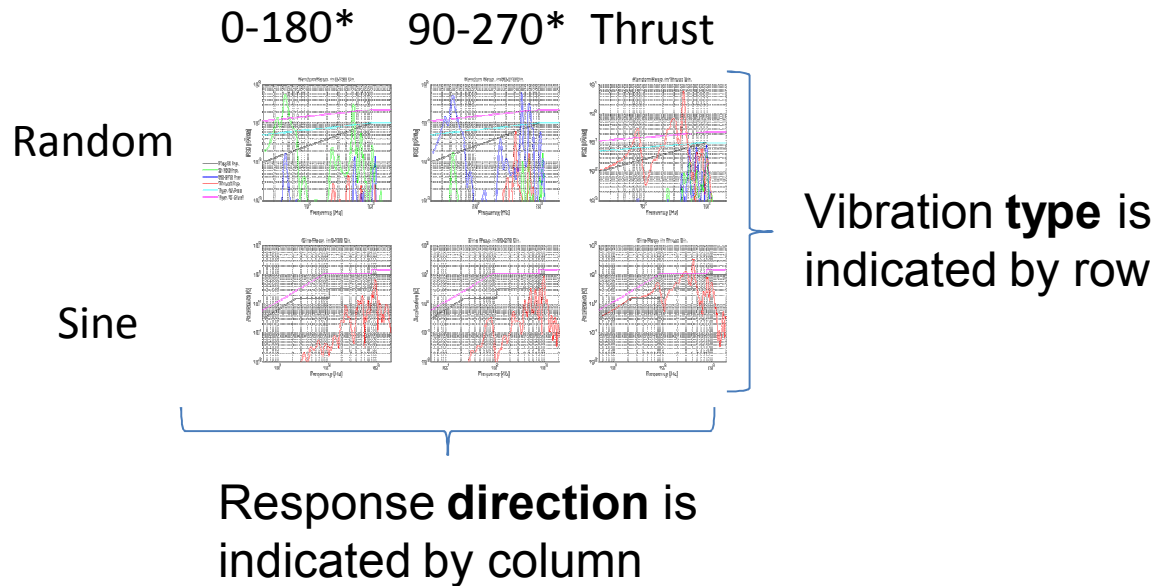


Finite Element Response Locations

Description	Node
Control	101
Telescope Spider Structure Center of Telescope	2427
Primary Mirror	25865
Telescope Primary Mirror Mount Ring	25168
Optical Bench Surface Near Waveplate Electronics Cold Plate	110119
Middle of the Optical bench Surface Near CIV Fold Mirror	114164
Mg-II Camera Mount	18919
CIV Camera	403
H Grating	25866
V Grating	25867
Spectrograph Structure at Grating End	23146



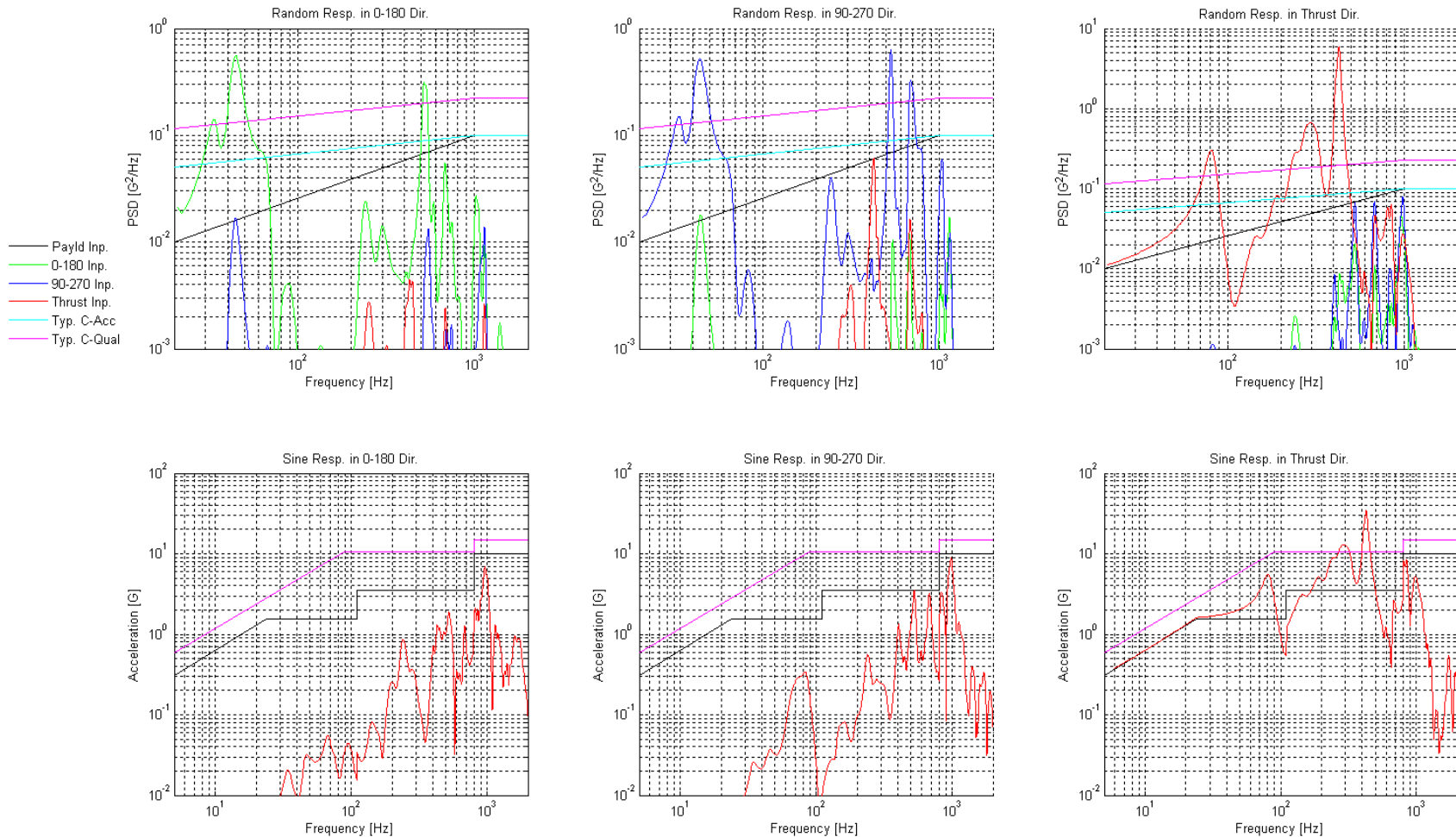
Response Plot Key



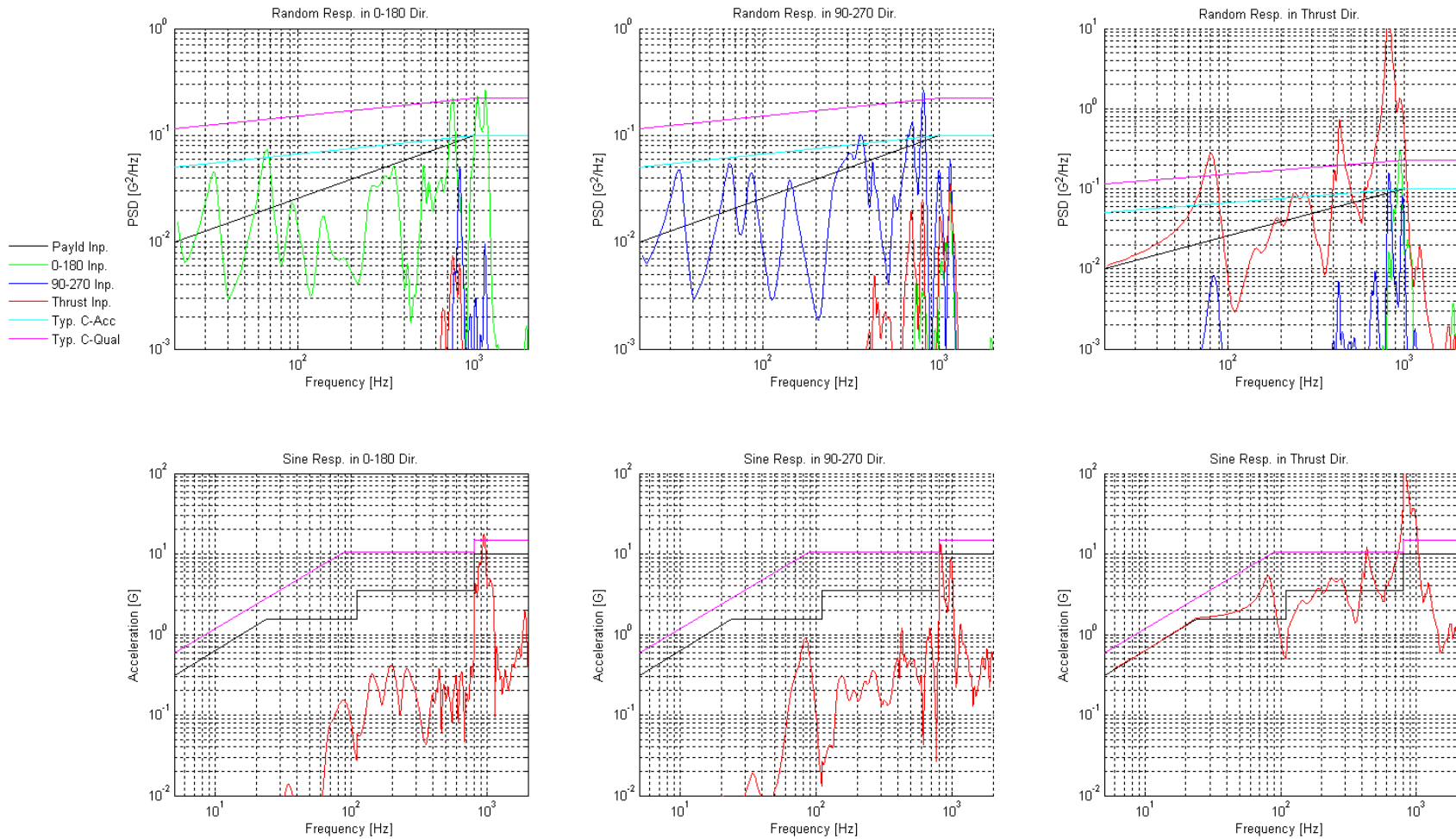
Line Color	Line Represents:
	Response resulting from Thrust Input Excitation
	Response resulting from 0-180 Input Excitation
	Response resulting from 90-270 Input Excitation
	Input Excitation at the Base of the Payload
	Typical Component Acceptance Level
	Typical Component Qualification Level

*0-180 and 90-270 are orthogonal base shake or response directions in the two lateral axes

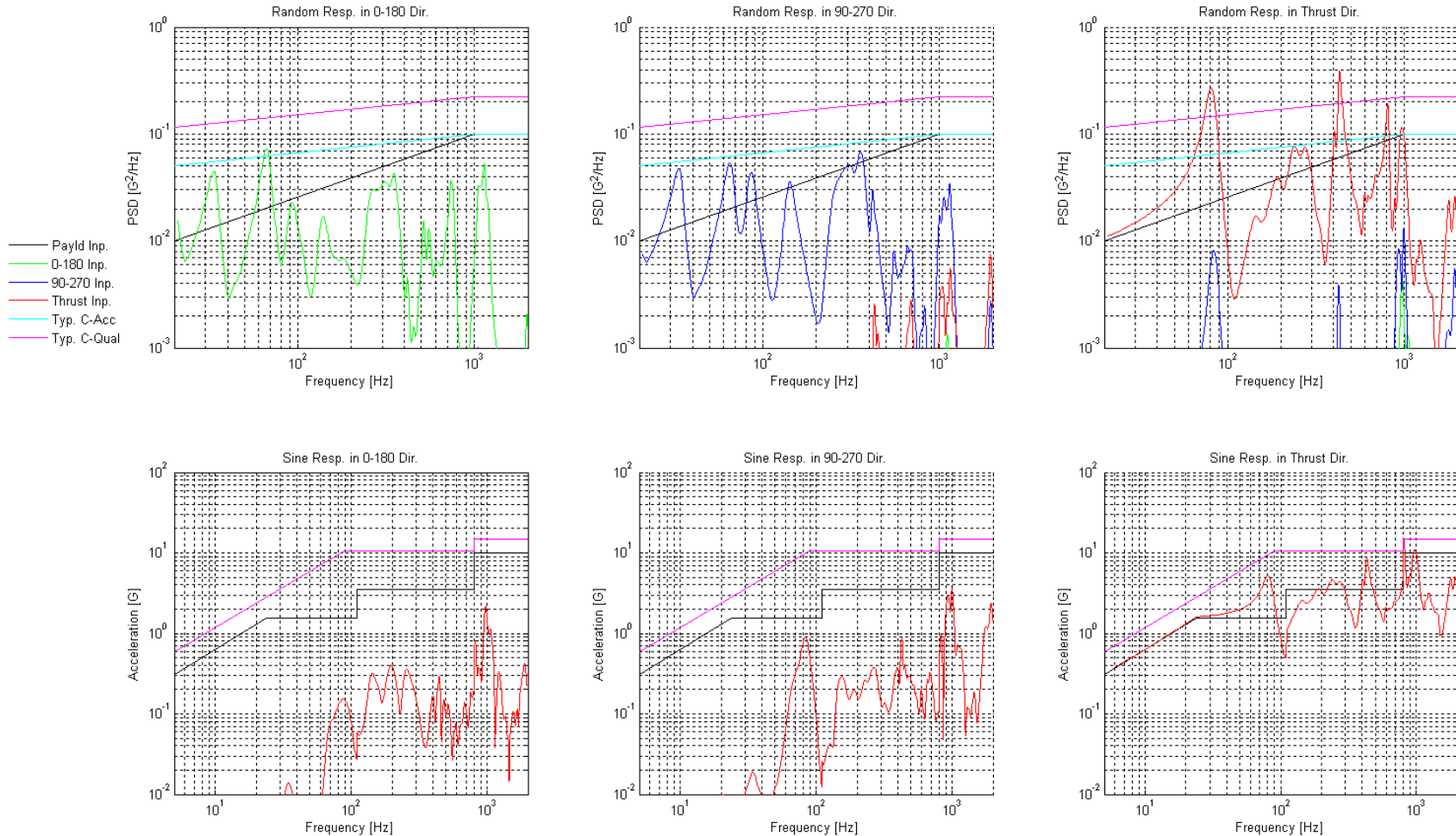
Telescope Spider Structure Center of Telescope



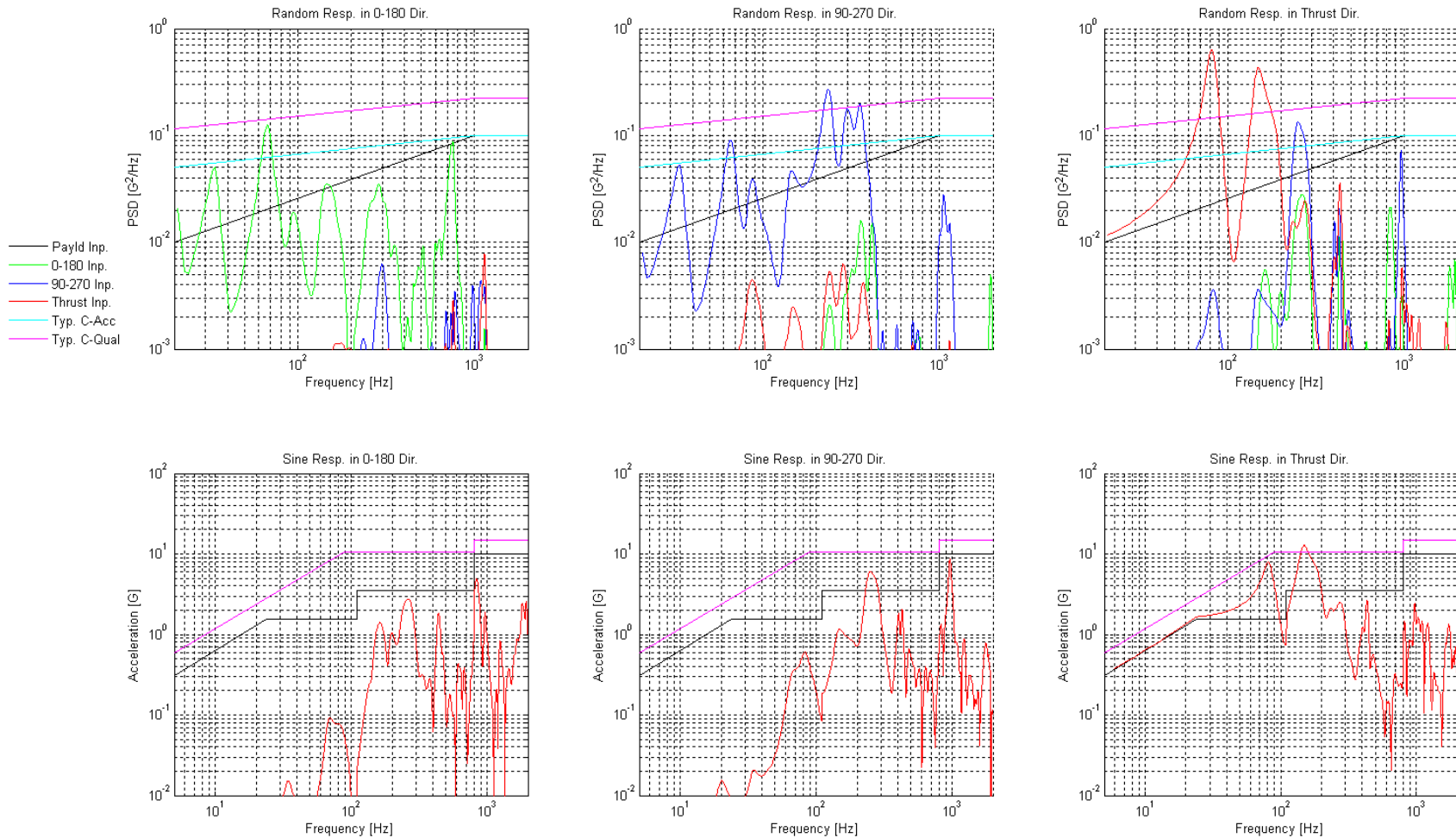
Primary Mirror



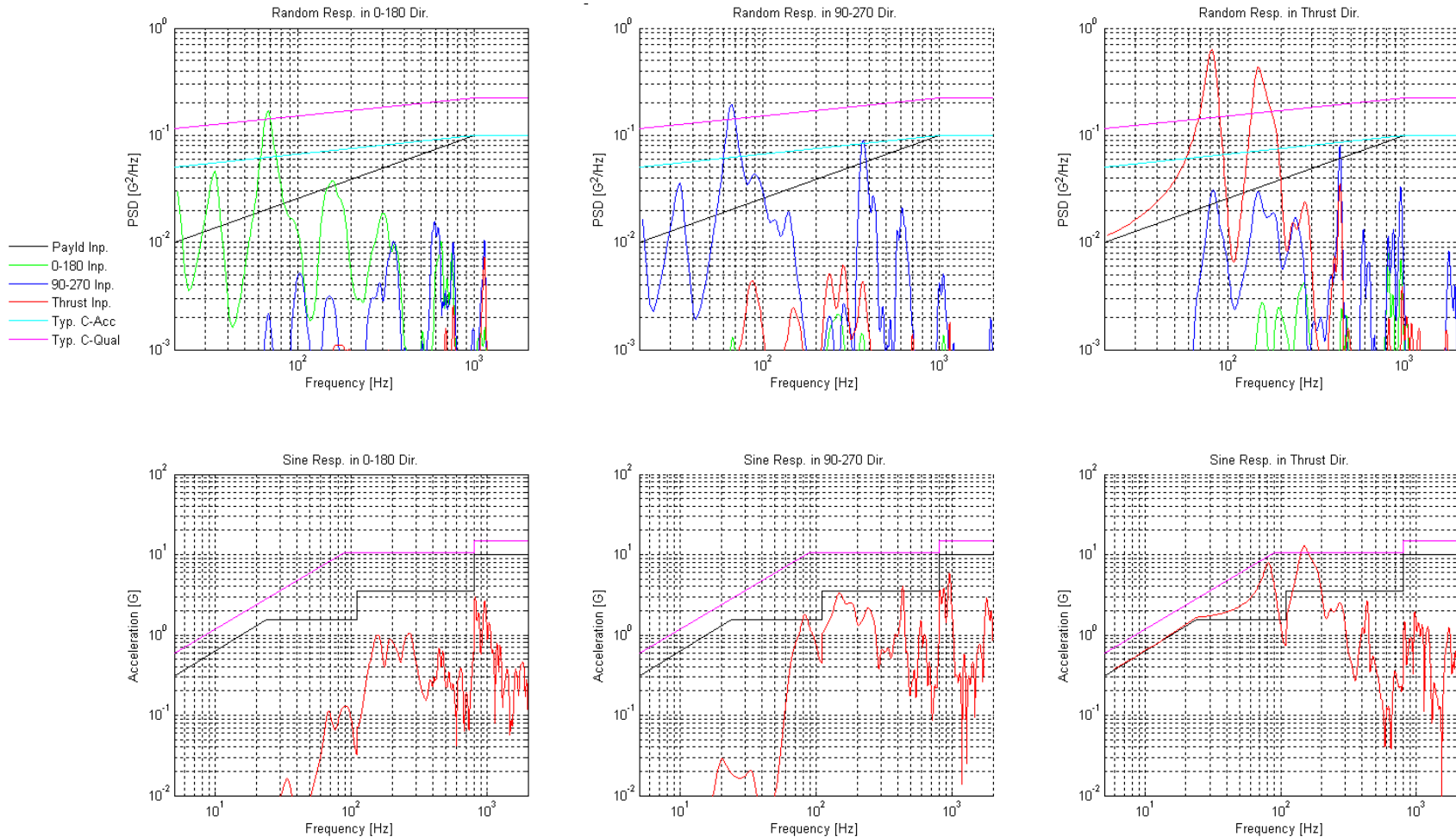
Telescope Primary Mount Ring



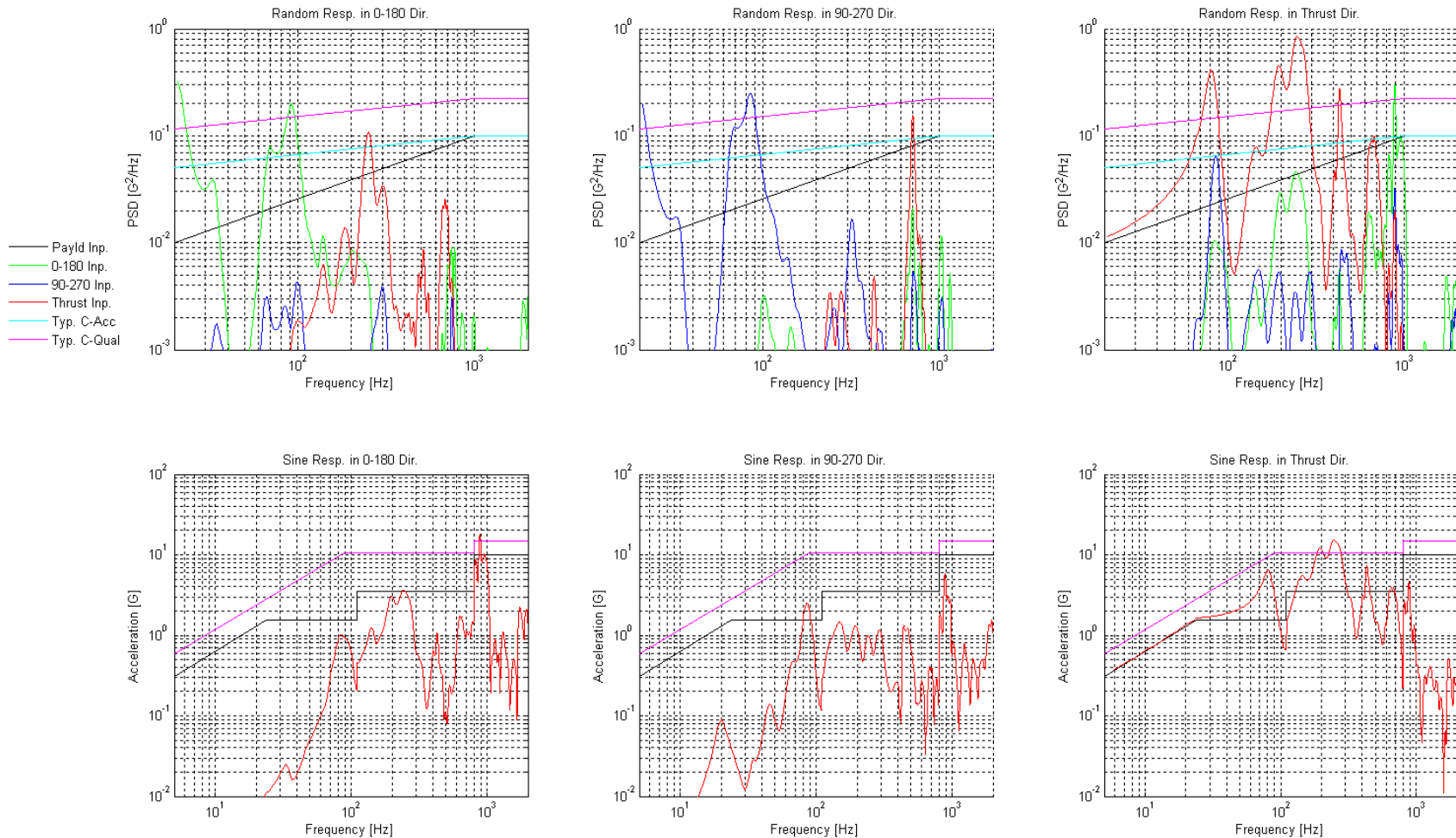
Optical Bench Surface Near Waveplate Electronics Cold Plate



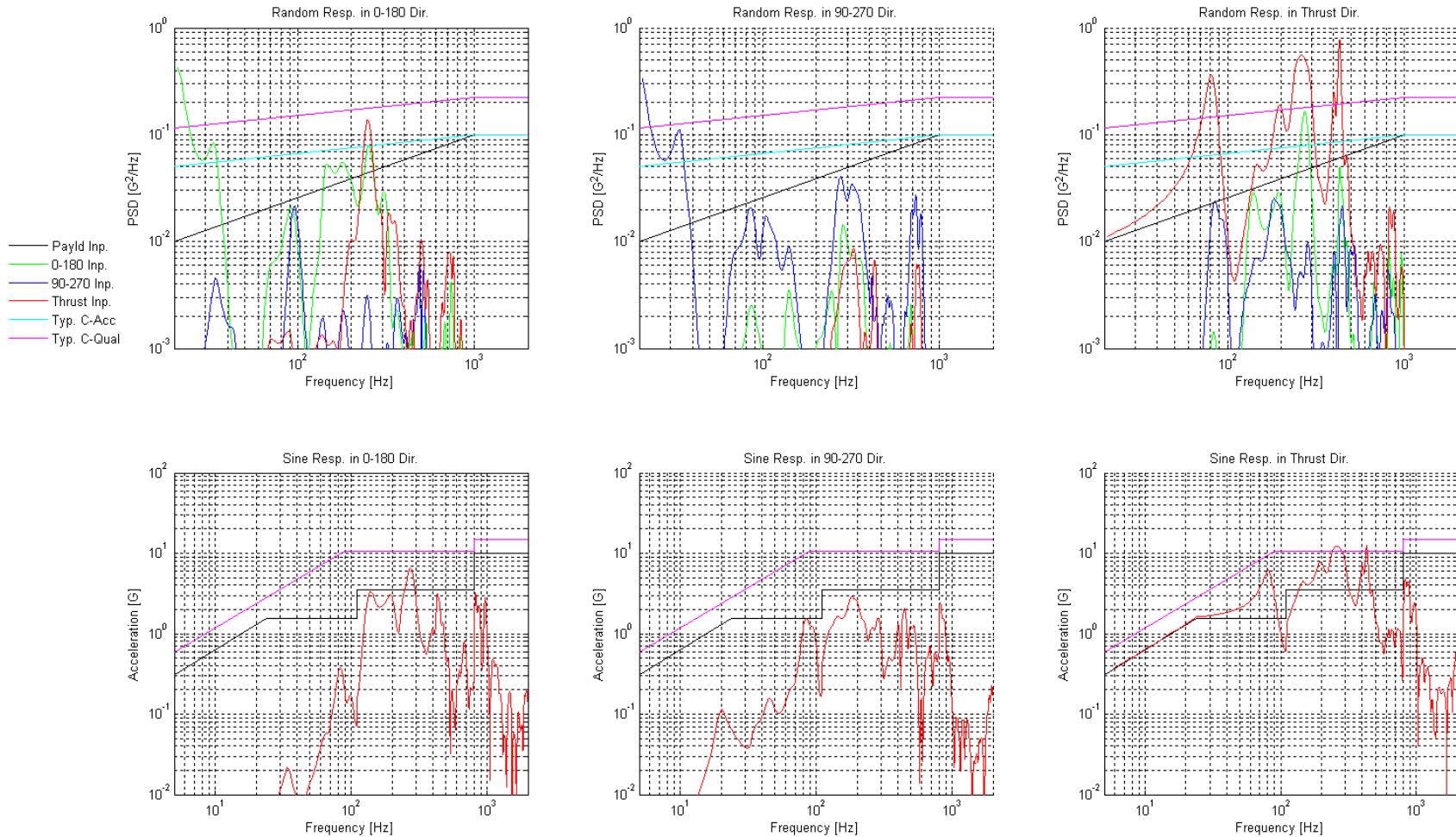
Middle of the Optical Bench Near CIV Fold Mirror



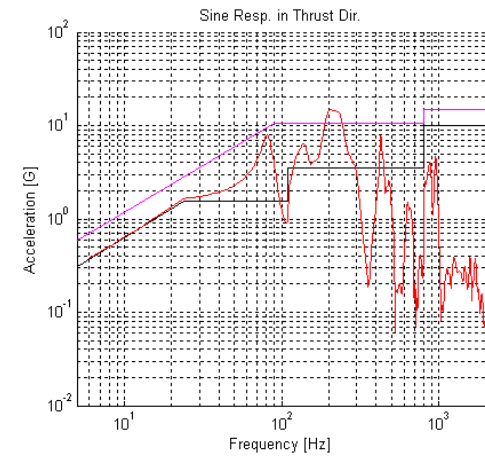
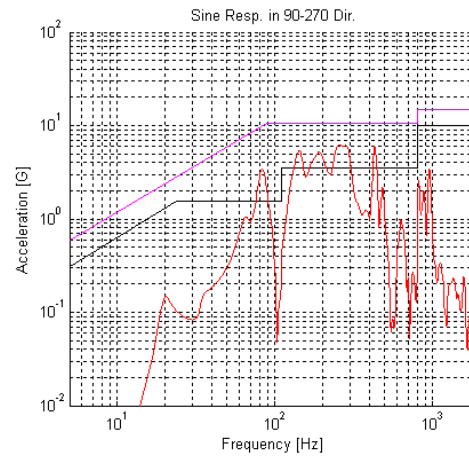
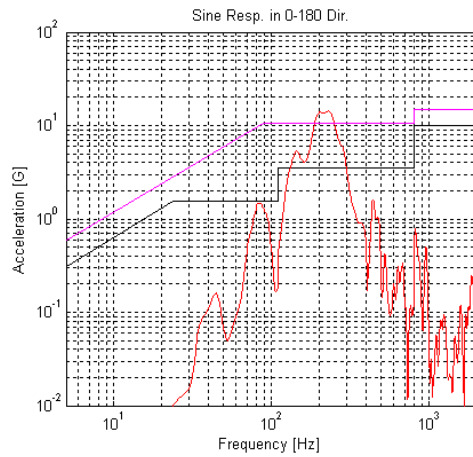
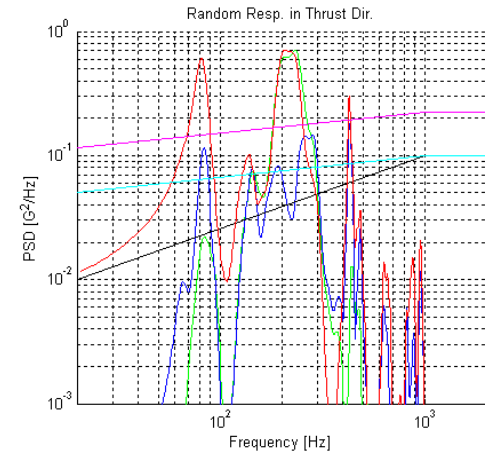
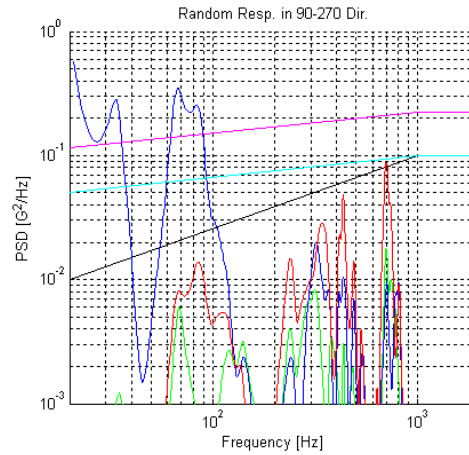
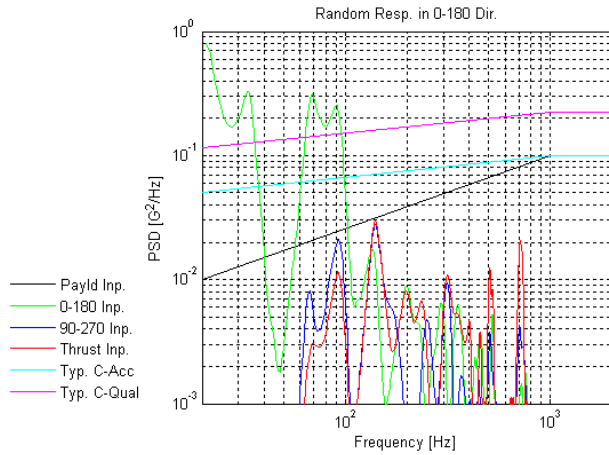
Mg-II Camera Mount



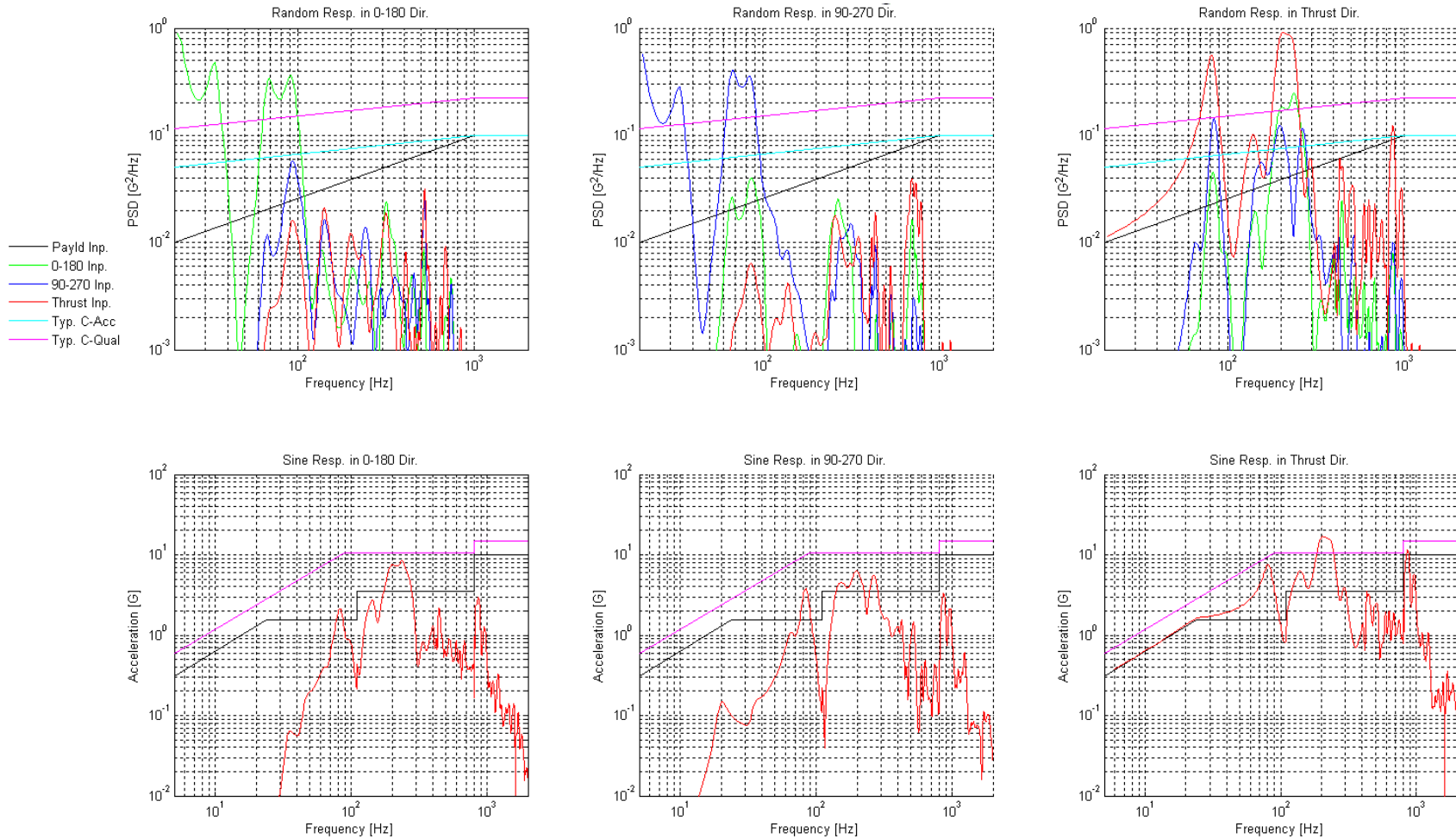
CIV Camera



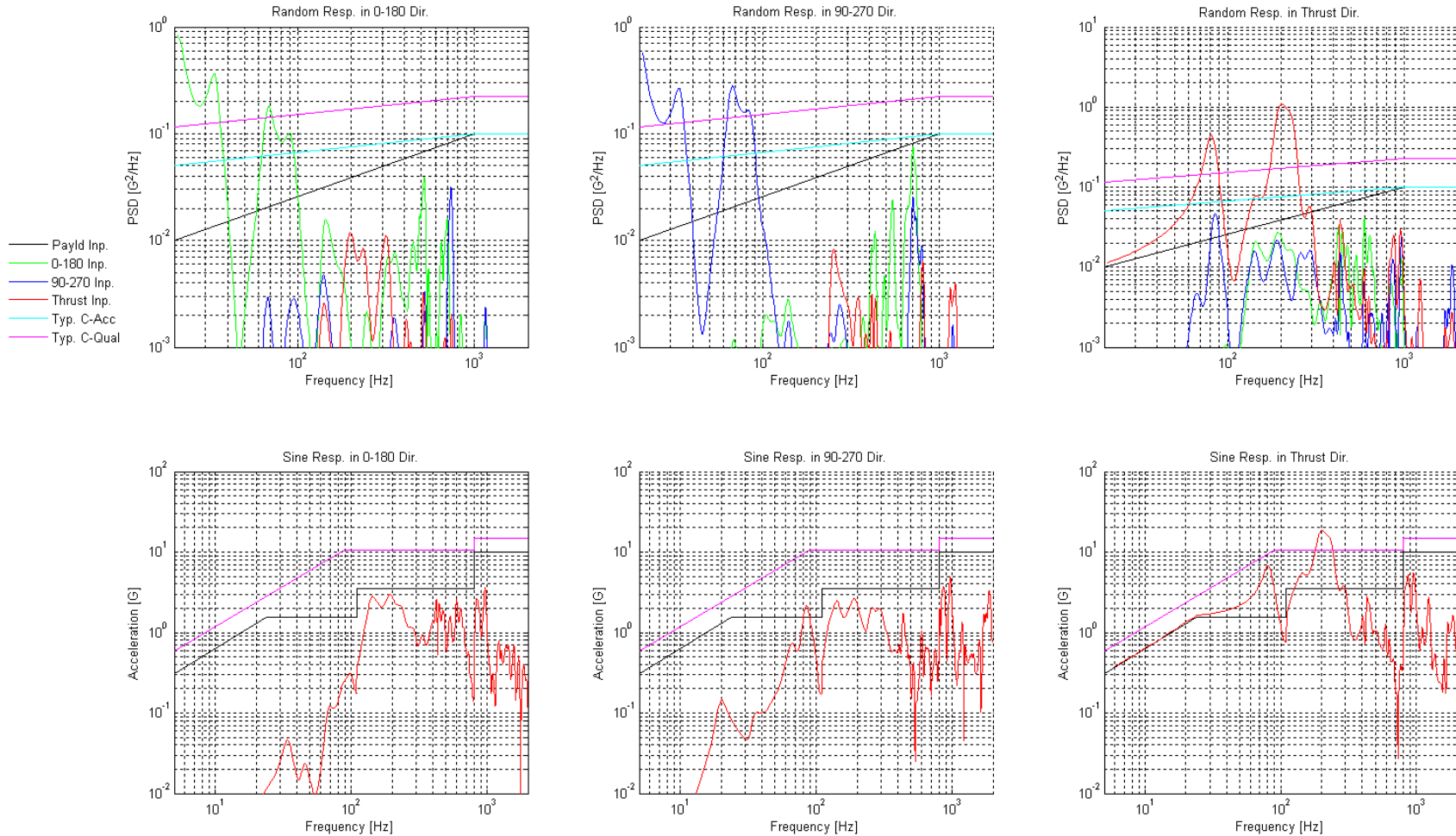
H Grating



V Grating



Spectrograph Structure at Grating End

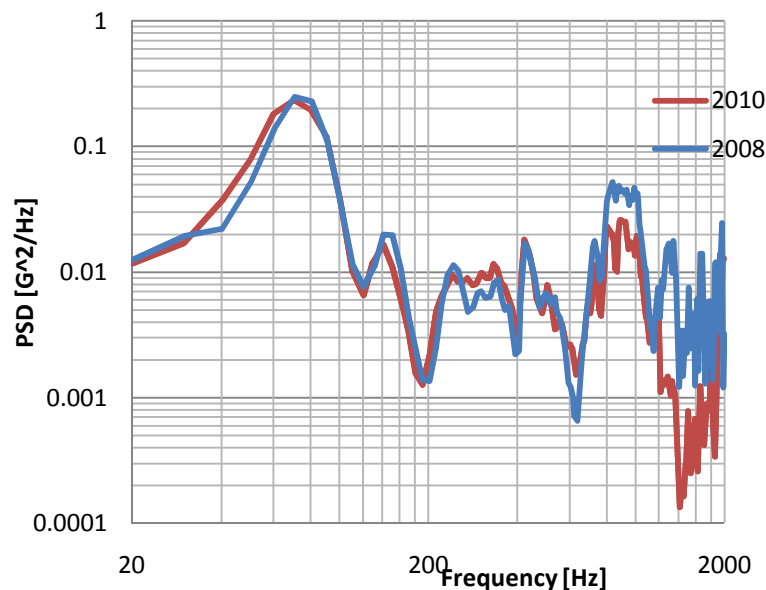


Findings/Conclusions

- The first lateral bending modes of the rocket amplify the low frequency responses of components near the top of the experiment. The result is that these same components are significantly isolated from high frequency vibrations in the 0-180 and 90-270 directions.
- Small, high natural frequency avionics are less likely to be damaged by the amplified low frequency vibration and if oriented properly, can be spared the more damaging high frequency environments.
- If possible, avoid aligning the most sensitive axis of a component with the thrust axis. i.e. The most sensitive axis for a circuit card is the surface normal.

Findings/Conclusions

- Finite element results at high frequency can be unreliable. For that matter, even high frequency test data can be very inconsistent. The “same” test and what was purportedly the “same” response location on sounding rocket payload test showed dramatically different high frequency responses. Low anticipated levels at high frequency should not necessarily be used to justify low component test criteria.



Findings/Conclusions

- The response data presented may be of value for estimating design environments for other similar payloads or experiments. The users are encouraged to recognize that the new design will produce somewhat different response. Therefore, using these results to construct smoothed envelope vibration environment criteria may be appropriate. These vibration design envelope criteria should make use of uncertainty where the component response frequencies are concerned. Magnitude uncertainty would also be appropriate in the early stages of design.